

950 c.c. gave 4.5 c.c. This corresponds to about 0.4 per cent. of indifferent gas. The first portion was unfortunately lost, but the spectrum of the second portion was carefully compared with that of argon, and the lines were all found to be coincident. No new lines appeared, nor was any helium yellow visible.

An incombustible gas from another well at the same place was also tested, and was found to contain 0.5 per cent. of argon (Kellas).

Some gas from a boiling spring near Reykjavik, Iceland, was collected last autumn (Ramsay), and, on removing the combinable constituents, 7.45 c.c. were obtained from 660 c.c. of the gas. This is a greater proportion of argon than is present in air, being 1.14 per cent. No helium could be detected in the gas, nor were there any lines which could not be recognised as belonging to argon.

It has been thought worth while to place on record these experiments, although they show nothing remarkable. We have to express our indebtedness to Mr. Noel Heaton for help kindly rendered.

IV. "Contributions to the Mathematical Theory of Evolution. III. Regression, Heredity, and Panmixia." By KARL PEARSON, University College, London. Communicated by Professor HENRICI, F.R.S. Received September 28, 1895.

(Abstract.)

THE object of this paper is to develop the methods and generalise the conclusions of Mr. Francis Galton's work on 'Natural Inheritance.' It endeavours to show the wide field which a purely statistical (as distinguished from a mechanical or physiological) theory of heredity may be made to cover. In order to do this it is needful to define certain biological terms in such a manner that they are capable of quantitative measurement, the symbols in terms of which they are expressed being the standard-deviations, correlation-coefficients, and regression-coefficients already well known from the labours of Mr. Galton. The fundamental assumption made is that the distribution of variation in any organ or characteristic follows the normal law. It is pointed out that this distribution, although very general, is not absolute, and that, especially in cases of disease and heredity, we require the consideration of skew-variation and skew-correlation.

The quantities mathematically defined are variation, correlation, natural, sexual and reproductive selection, heredity, regression, and panmixia. The definitions given agree in part with those already adopted by Mr. Galton or Professor Weldon. At some points they extend or develop the ideas of those naturalists. In particular the author finds it necessary to emphasise the distinction between two

types of sexual selection resulting from tribal and individual tastes, and leading respectively to a preferential and an assortative mating. The mathematical measurement of the latter (which seems a sensible, if small, quantity in the case of stature in man) is not quite identical with Darwin's conception of sexual selection, which approximates rather to preferential mating. The memoir develops Bravais' theory of correlation, determining the probable error of the determination of a coefficient of correlation and the relation of a coefficient of correlation to coefficients of variation. The analytical forms for two, three, or four correlated variables are given, and a proof of Edgeworth's theorem. These results are applied to the problems of correlation in local races, of biparental inheritance, collateral inheritance, morbid inheritance, and some problems in 'cross' heredity. Finally, the problem of panmixia is dealt with. The following results among others are deduced; they are, however, to be considered in each case as probable only, and matter for closer investigation and observation* :—

(a.) It is improbable that coefficients of correlation are absolutely constant for local races.

(b.) To judge by stature, the father, in the case of both sons and daughters, is markedly more prepotent in inheritance than the mother. Heredity is thus markedly stronger in the male than the female line.

(c.) Fathers of sons are less variable than fathers of daughters. Very tall or very short fathers have more daughters than sons.

(d.) There is a sensible sexual selection in man.

(e.) There is some evidence of reproductive selection.

(f.) Regression is not the same in the case of ascent and descent in the direct line.

(g.) Elder sisters are shorter and less variable than younger sisters.

(h.) Biparental inheritance is sensibly influenced by sexual selection, the general tendency of the latter being to *lessen* the hereditary tendency.

(i.) The mathematical theory appears capable of covering such phenomena as "skipped generations" and the "antedating of hereditary diseases."

(j.) Sports breed just as true as a race established by long and continuous selection.

(k.) According as the "focus of regression" is considered stationary or progressive with long-continued selection, panmixia will or will not tend to reverse natural selection, both as to magnitude of mean and amount of variation.

(l.) A stationary focus of regression, besides an obvious difficulty

* Conclusions (b)–(g) are based upon applications of the theory to family data of stature kindly placed at my disposal by Mr. Galton.

as to where it can be placed short of the zero advocated by some supporters of panmixia, involves either a mortality due to periodic selection or a magnitude of the regression coefficient vastly greater than any which are in the least supported by such statistics as have hitherto been collected.

(*m.*) Natural selection is more rapid in its effects when unaccompanied, than when accompanied, by that form of sexual selection which has been termed assortative mating.

V. "On the Granular Leucocytes." By G. LOVELL GULLAND, M.A., B.Sc., M.D., F.R.C.P.E. Communicated by J. N. LANGLEY, F.R.S. Received August 27, 1895.

(Abstract.)

Leucocytes whose finer structure is to be examined must be fixed by reagents, of which the best is sublimate; drying is unreliable, as it does not preserve details of structure.

It is impossible to divide leucocytes into a hæmal variety and a cœlomic variety, for (1) lymphocytes are the precursors of all forms; (2) leucocytes are not present in the blood in early foetal life; (3) they are constantly passing from blood to connective tissue and *vice versa*; (4) the mitotic reproduction of leucocytes takes place almost entirely in adenoid tissue. It is only their size which prevents the largest hyaline, eosinophile, and basophile cells from appearing in the blood.

M. Heidenhain's observations on the relative positions of nucleus and centrosomes are correct, but his theory of the original equality of the "organic radii" will not hold. These main threads of the mitoma are connected at every microsome by subsidiary threads. The nucleus does not lie free in the interfilar spaces, but its linin network is connected with the cytomitoma, and the two are perhaps to a certain extent interchangeable. This would explain the variety of arrangement of the nuclear chromatin, and the co-ordination in movement of the cell-body and nucleus.

The shape of the nucleus has no relation to the presence or absence of granules in the cell-body, but depends on (1) the relative sizes of the cell-body and nucleus (according to M. Heidenhain's law); (2) the position of the centrosomes; (3) the condition of rest or movement of the cell.

All varieties of leucocytes are merely stages in the development of a tissue. They may be divided for convenience, and with regard to the presence or absence of granules, into three main groups, the Hyaline, Acidophile, and Basophile. These forms are all derived from the lymphocytes, which are the daughter-cells derived from the